CLAIMS

What is claimed is:

1. A method for determining a parameter of interest of a region of interest of the earth, the method comprising:
   (a) measuring at least one component of gravity data at a plurality of locations over a region of interest including a subterranean formation of interest;
   (b) determining an initial geophysical model of the region of interest including the subterranean formation of interest;
   (c) for said model, estimating a value of the gravity data at said plurality of locations using a High Order Compact Finite Difference method;
   (d) determining a difference between said estimated value and said measured value of said measurements at said plurality of locations;
   (e) updating the geophysical model of the region based on said difference;
   (f) iteratively repeating steps c-e until said difference is less than a predetermined value; and
   (g) using said model to determine the parameter of interest.

2. The method of claim 1 wherein said parameter of interest is selected from: i) an upward continued gravity field, ii) a downward continued gravity field, iii) an anomalous subsurface object, iii) a lower boundary of a subterranean formation, iv) a thickness of a subterranean formation, v) a density of the subterranean formation, vi) a magnetic susceptibility of the subterranean formation, vii) a volume of the subterranean formation, viii) overburden stress in the region of interest, ix) effective stress in the region of interest, x) formation fluid pressure in the region of interest, xi) overburden stress below a subterranean formation of interest, xii) effective stress below a subterranean formation of interest, and xiii) formation fluid pressure below a subterranean formation of interest.

3. The method of claim 1 wherein estimating a value of the gravity data at said plurality of locations using a High Order Compact Finite Difference method includes a conjugate gradient method.

4. The method of claim 1 wherein estimating a value of the gravity data at said plurality of locations using a High Order Compact Finite Difference method includes estimating at least one model observation point inside the volume of said region of interest of the earth.

5. The method of claim 1 wherein the subterranean formation of interest is one of the group consisting of (i) a salt body, (ii) a shale diapir, (iii) a volcanic flow, (iv) an intrusive igneous body, and, (v) an extrusive igneous body.

6. The method of claim 1 wherein the at least one component of gravity data is a gravity component, the method further comprising applying to the at least one component of the gravity data for at least one of (i) a latitude correction, (ii) a free air correction, (iii) a fixed density Bouguer correction, (iv) a variable density Bouguer correction, (v) Eotvos correction, and (vi) datum correction.

7. The method of claim 1 wherein the model is selected from (i) a 2D model, (ii) a 2.5D model, (iii) a 2.75D model, and (iv) a 3-D model.

8. The method of claim 1 further comprising incorporating in the model at least one of (i) land topography, (ii) marine sea surface, and (iii) water bottom bathymetry.

9. The method of claim 1 wherein density of the subterranean formation in the determined geophysical model is at least one of (i) a fixed density, (ii) a laterally varying density, and (iii) a vertically varying density.

10. The method of claim 1 wherein determining the initial geophysical model further comprises acquiring and processing seismic data over the region of interest and using the seismic data to derive the geophysical model therefrom.

11. The method of claim 10 wherein processing the seismic data further comprises:

i) determining seismic velocities in the region from the acquired seismic data; and

ii) using an empirical relation between seismic velocities and densities in determining a geophysical model of density.

12. A method for processing gravity and gravity tensor data, the method comprising:

(a) measuring at least one component of gravity and gravity tensor data at a plurality of locations over a region of interest including a subterranean formation of interest;

(b) determining an initial geophysical model of the region including the subterranean formation of interest;

(c) for said model, estimating a value of said at least one component of geophysical tensor data at said plurality of locations based on a forward model of gravity data using a High Order Compact Finite Difference method;

(d) determining a difference between said estimated value and said measured value of said measurements at said plurality of locations;

(e) updating the forward model based on said difference;

(f) iteratively repeating steps c - e until said difference is less than a predetermined value; and

(g) using said updated forward model to determine at least one component of gravity and gravity tensor data at a plurality of locations.

13. The method of claim 12 wherein the subterranean formation of interest is one of the group consisting of (i) a salt body, (ii) a shale diapir, (iii) a volcanic flow, (iv) an intrusive igneous body, and, (v) an extrusive igneous body.

14. The method of claim 12 wherein the at least one component of gravity and gravity tensor data comprises at least two components of gravity and gravity tensor data, and the method further comprises filtering the at least two components to give filtered data components that are consistent with Poisson's equation.

15. The method of claim 12 wherein the method further comprises applying to the at least one component of gravity and gravity tensor data at least one of (i) a latitude correction, (ii) a free air correction, (iii) a fixed density Bouguer correction, (iv) a variable density Bouguer correction, (v) Eotvos correction, and (vi) datum correction.

16. The method of claim 12 wherein the model is selected from (i) a 2D model, (ii) a 2.5D model, (iii) a 2.75D model, and (iv) a 3-D model.

17. The method of claim 12 further comprising incorporating in the initial geophysical model at least one of (i) land topography, (ii) marine sea surface, and (iii) water bottom bathymetry.

18. The method of claim 12 wherein density of the initial geophysical model is at least one of (i) a fixed density, (ii) a laterally varying density, and (iii) a vertically varying density.

19. The method of claim 12 further comprising inverting at least two components of gravity and gravity tensor data so that said inverted components satisfy Poisson's equation simultaneously.

20. The method of claim 19 wherein iteratively repeating steps (c) - (e) of claim 1 further comprises solving for the gravity and gravity tensor data simultaneously.